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THE PRESENT PROBLEMS OF ORGANIC EVOLUTION.

THE doctrine of evolution may be defined as the teaching which holds that creation has been and is accomplished by the agency of the energies which are intrinsic in the evolving matter, and without the interference of agencies which are external to it. It holds this to be true of the combinations and forms of inorganic nature, and of those of organic nature as well. Whether the intrinsic energies which accomplish evolution be forms of radiant or other energy only, acting inversely as the square of the distance, and without consciousness, or whether they be energies whose direction is affected by the presence of consciousness, the energy is a property of the physical basis of tridimensional matter, and is not outside of it, according to the doctrine we are about to consider.

As a view of nature from an especial standpoint, evolution takes its place as a distinct science. The science of evolution is the science of creation, and is as such to be distinguished broadly from the sciences which consider the other operations of nature, or the functioning of nature, which are not processes of creation, but processes of destruction. This contrast is especially obvious in organic evolution, where the two processes go on side by side, and are often closely intermingled, as for instance in muscular action, where both destruction of proteids and growth of muscular tissue result from the same acts, or use. Physiology, or the science of functions, concerns itself chiefly with destruction, and hence physiologists are especially prone to be insensible to the phenomena and laws of progressive evolution. The building of the embryo, remains a sealed book to the physiologist unless he take into account the allied bioogical science of evolution, as resting on the facts of botany, zoölogy, and paleontology. In his reflexions on the relations of mind to matter he is likely to see only the destructive functioning of tissue, and not the history of the building of the same during the ages of geological time.

J. B. P. A. Lamarck[1] thus contrasts the theories of direct creation, and creation by evolution. The former asserts: "That nature or its author in creating animals has foreseen all possible kinds of circumstances in which they may have to live, and has given to each species a permanent organisation as well as a predetermined form, invariable in its parts; that it forces each species to live in the place and the climate where one finds them, and to preserve there the habits which it has." He then states his own, or the evolutionary, opinion to be: "That nature in producing successively all species of animals, commencing with the most imperfect or simple, and terminating its work with the most perfect, has gradually complicated their organisation; and these animals spreading themselves gradually into all habitable regions of the globe,—each species has been subjected to the influence of the circumstances in which it is; and these have produced the habits which we observe, and the modifications of its parts." On an earlier page of the same chapter, Lamarck thus formulates the laws of organic evolution, to which his name has been attached.

First law. "In every animal which has not passed the time of its development, the frequent and sustained employment of an organ gradually strengthens it, develops and enlarges it, and gives it power proportional to the duration of its use; while the constant disuse of a like organ weakens it, insensibly deteriorates it, progressively reduces its functions, and finally causes it to disappear."

Second law. "All that nature acquires or loses in individuals by the influence of circumstances to which the race has been exposed for a long time, and in consequence of the influence of the predominate employment of such an organ, or of the influence of disuse of such part, she preserves by generation, in new individuals which spring from it, providing the acquired changes be common to both sexes, or to those which have produced new individuals."

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[1] *Philosophie Zoologique*, Paris, 1809, Vol. I., Chap. VII.

We have here a theory of the origin of characters; viz., of the increased development or loss of parts as a result of use or disuse. We have also the theory that the peculiarities thus acquired are transmitted to the succeeding generation by inheritance.

The next formal statement of the efficient cause of organic evolution was presented by Messrs. Charles Darwin and Alfred R. Wallace in 1859.[1] The cause assigned is natural selection, and Mr. Darwin thus states what is meant by this expression in his work *The Origin of Species.*[2] "If under changing conditions of life organic beings present individual differences in almost any part of their structure, and this cannot be disputed; if there be, owing to their geometrical rate of increase, a severe struggle for life at some age, season, or year, and this certainly cannot be disputed; then considering the infinite complexity of the relations of all organic beings to each other and to their conditions of life, causing an infinite diversity of structure, constitution, and habits, to be advantageous to them, it would be a most extraordinary fact if no variations had ever occurred useful to each being's own welfare, in the same manner as so many variations have occurred useful to man. But if variations useful to any organic being ever do occur, assuredly individuals thus characterised will have the best chance of being preserved in the struggle for life; and from the strong principle of inheritance, these will tend to produce offspring similarly characterised. The principle of preservation, or the survival of the fittest, I have called natural selection. It leads to the improvement of each creature in relation to its organic and inorganic conditions of life; and consequently in most cases, to what must be regarded as an advance in organisation. Nevertheless, low and simple forms will long endure if well fitted for their simple conditions of life."

It is readily perceived that this statement makes no attempt to account for the origin of variations, but that it simply formulates, as observed by Mr. Darwin, the doctrine of survival of such variations as are most useful to their possessors. This fact is more distinctly pointed out in the same work (p. 63) where the author remarks: "Several writers have misapprehended or objected to the term natural selection. Some have even imagined that natural selection induces variability, whereas it implies only the preservation of such variations as arise and are beneficial to the being under its conditions of life. No one objects to agriculturists speaking of the potent effects of man's selection, and in this case the individual differences given by nature, which man for some object selects, must of necessity first occur." It is evident then that Mr. Darwin did not attempt to account for the origin of variations, but that the service rendered by him and by Mr. Wallace to the doctrine of evolution consists in the demonstration of the reality of natural selection. Darwin also assumes in the statement first quoted above, the inheritance of acquired characters.

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[1] *Proceedings of the Linnean Society of London.*

[2] Ed. 1872, p. 102.

In 1865 the *Principles of Biology* of Herbert Spencer appeared. In this work the attempt is made to set forth the laws of organic evolution, in a way which represents an advance beyond the positions of his predecessors. He adopts and harmonises both the Lamarckian and Darwinian doctrines, and is at times more specific in his application of Lamarck's doctrine of the stimulus of the environment, and of use, than was Lamarck himself. Very often, however, Spencer contents himself with generalities; or takes refuge in the "instability of the homogeneous," as an efficient cause. This phrase, however, like his other one, "the unknowable," is but a makeshift of temporary ignorance, and is neglected by Spencer himself, when he can see his way through it. He approaches the cause of the varied forms of leaves of plants in this language:[1] "And it will also be remembered that these equalities and inequalities of development correspond with the equalities and inequalities in the incidence of forces." Language of similar significant but rather indefinite import is frequently used throughout this volume.

But in some cases Spencer is more specific. With reference to the inequality in the basal lobes of the erect leaves of Tilia and other plants, he says:[1] "A considerable deviation from bilateral symmetry may be seen in a leaf which habitually so carries itself that the half on the one side of the midrib is more shaded than the other half. The drooping branches of the lime show us leaves so arranged and so modified. On examining their attitudes and their relations one to another, it will be found that each leaf is so inclined that the half of it next the shoot grows over the shoot and gets plenty of light; while the other half so hangs down that it comes a good deal into the shade of the preceding leaf. The result is that having learned which fall into these positions, the species profits by a large development of the exposed halves; and by survival of the fittest acting along with the direct effect of extra exposure, this modification becomes established." In his discussion of the origin of the characters of animals, Spencer is also sometimes specific. Respecting the development of muscular insertions he remarks:[2] "Anatomists easily discriminate between the bones of a strong man and those of a weak man by the greater development of those ridges and crests to which the muscles are attached; and naturalists on comparing the remains of domesticated animals with those of wild animals of the same species, find kindred differences. The first of these facts shows unmistakably the immediate effect of function on structure, and, by obvious alliance with it, the second may be held to do the same, both implying that the deposit of dense substance capable of great resistance habitually takes place at points where the tension is excessive." Quite as specific is his ascription of the forms of epithelial cells to definite causes, as follows:[3] "Just the equalities and inequalities of dimensions among aggregated cells, are here caused by the equalities and inequalities among their mutual pressures in different directions; so, though less manifestly, the equalities and inequalities of dimensions among other aggregated cells, are caused by the equalities and inequalities of the osmatic, chemical, thermal, and other forces besides the mechanical, to which their different positions subject them."

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[1] *The Principles of Biology*, by Herbert Spencer, Amer. Ed., 1873, II., p. 143.

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[1] *Op. cit.*, p. 143.

[2] *Loc. cit.*, p. 200.

[3] *Op. cit.*, p. 260.

In spite of this not infrequent definiteness, Mr. Spencer occasionally falls into the error of ascribing the origin of structures to natural selection, as in the case of the forms of flowers,[1] and the armor-plates of paleozoic fishes.[2] Spencer assumes the inheritance of acquired characters throughout.

In 1866 Haeckel's *Schöpfungsgeschichte* appeared. In this work the author presents a mass of evidence which sustains the doctrine of evolution, and he combines the views of Lamarck and Darwin into a general system. He says:[3] "We should, on account of the grand proofs just enumerated, have to adopt Lamarck's theory of descent for the explanation of biological phenomena, even if we did not possess Darwin's theory of selection. The one is so completely and directly proved by the other, and established by mechanical causes, that there remains nothing to be desired. The laws of inheritance and adaptation are universally acknowledged physiological facts, the former traceable to propagation, the latter to the nutrition of organisms." Apart from the statement that adaptation is traceable "to the nutrition of organisms," we find nothing in Haeckel's earlier writings which attempts the explanation of the origin of variations, beyond the general position assumed by Lamarck. The distinctive merit of Haeckel is his formulation of phylogeny. Much of this was speculative at the time he wrote, but so far as the Vertebrata are concerned, it has been largely confirmed by subsequent discovery.

Up to this period, the form in which the doctrine of evolution had been presented, was general in its application; that is, without exact reference to the structural definitions of natural taxonomic groups. No attempt was made to show the modes of the origin of any particular class, order, or genus, and only in the most general way in the case of a few species, by Mr. Darwin. Phylogeny was untried, except by Haeckel; and this distinguished author did not attempt to account specifically for the origins of the divisions whose filiations he set forth.

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[1] *Op. cit.*, p. 153.

[2] *Op. cit.*, p. 288.

[3] *The History of Creation*, Amer. Ed., II., p. 355.

In the year in which Haeckel's work above cited appeared, Professor Hyatt of Boston and myself took the first step towards the formulisation of a rational theory of the origin of variation, which should accord with specific examples of taxonomy. Quite independently, we selected the simple series presented by the characters of genera in their natural relations, Hyatt in the cephalopodous Mollusca, and I in the Batrachia Salientia. It is probable that Hyatt's[1] article was published shortly before mine. He says of the genera of Cephalopoda: "In other words, there is an increasing concentration of the adult characteristics in the young of higher species and a consequent displacement of other embryonic features which had themselves also previously belonged to the adult period of still lower forms." My own language is:[2] "That the presence, rudimental condition, or absence of a given generic character can be accounted for on the hypothesis of a greater rapidity of development in the individuals of the species of the extreme type, such stimulus being more and more vigorous in the individuals of the types as we advance towards the same, or by a reversed impulse[3] of development, where the extreme is characterised by absence or 'mutilation' of characters." The phenomena of the aggregation of characters in progressive evolution, and the loss of characters in retrogressive evolution, were termed by me acceleration and retardation in an essay published in 1869.[4] In these papers by Professor Hyatt and myself is found the first attempt to show by concrete examples of natural taxonomy, that the variations that result in evolution are not multifarious or promiscuous, but definite and direct, contrary to the method which seeks no origin for variations other than natural selection. In other words, these publications constitute the first essays in systematic evolution that appeared. To the explanation of the relations discovered by this research I applied the Lamarckian doctrine of use (or motion) and disuse, and added to that doctrine the effects on animal movements which result from the mental state called effort, in 1871.[1] This constitutes the earliest attempt, so far as I am aware, to demonstrate the influence of mind on organic evolution. Since that period my discoveries in the phylogeny of the Vertebrata through paleontologic investigations in North America have enabled me to present rational explanations for the origin and evolution of a number of particular groups.[2] Important contributions to corresponding histories of the Mollusca have been made by Hyatt,[3] Dall,[4] Jackson,[5] and Beecher.[6] Many other contributions, into which the paleontologic evidence does not enter, have also been made by various authors in Europe and America.

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[1] *Memoirs Boston Society Natural History*, 1866, p. 193.

[2] *Transactions American Philosophical Society*, 1856, p. 398; reprinted in *The Origin of the Fittest*, p. 92.

[3] The expression "reversed" is unfortunate, *diminished* being the proper word to convey the meaning intended.

[4] *The Origin of Genera*, Philadelphia, 1869.

The authors quoted up to this point had all assumed that the progress of evolution depends on the inheritance by the offspring of new characters acquired by the parent, and had believed that such is the fact in ordinary experience. In 1883, Weismann, in an essay on heredity, announced the opinion that characters acquired by the body could not be transmitted to the reproductive cells, and could not therefore be inherited. This doctrine rests on the relation of the germ-cells to those of the rest of the body, which is expressed in the following language of his predecessor Jaeger: "Through a great series of generations the germinal protoplasm retains its specific properties, dividing in every reproduction into an ontogenetic portion and a phylogenetic portion, which is reserved to form the reproductive material of the mature offspring. This reservation of the phylogenetic material I described as the continuity of the germ-protoplasm. . . . Encapsuled in the ontogenetic material the phylogenetic protoplasm is sheltered from external influences, and retains its specific and embryonic characters." In other words, the reproductive cells are removed from the influence of those stimuli which affect and effect growth in the cells of the other parts of the body, so that no character acquired by the rest of the body can be inherited. The bearing of this theory on evolution is thus stated by Weismann:[1] "The origin of hereditary individual variations cannot indeed be found in the higher organisms, the metazoa and metaphyta, but is to be sought for in the lowest, the unicellular." "The formation of new species, which among the lower protozoa could be achieved without amphigony (sexual union), could only be attained by means of this process in the metazoa and metaphyta. It was only in this way that hereditary individual differences could arise and persist." In other words, variation in organic beings above the unicellular forms, has been and is, introduced only by sexual reproduction.

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[1] "The Method of Creation," *Proceeds. Amer. Philos. Soc.*, 1871, December; *Origin of the Fittest*, 1887, p. 173.

[2] "The Origin of the Hard Parts of Mammalia," *American Journal of Morphology*, 1889, p. 137.

[3] "The Genesis of the Arietidæ," *Memoirs Mus. Compar. Zoölogy*, Cambridge, Mass., 1889, XVI., No. 3.

[4] Dall, W. H., "The Hinge of Pelecypods and Its Development," *Amer. Jour. Sci. Arts*, 1889, XXXVIII., p. 445.

[5] Jackson, R. T., "Phylogeny of the Pelecypoda, the Aviculidæ, and Their Allies,', *Memoirs Boston Soc. Nat. Hist.*, 1890, IV., p. 277.

[6] *American Journ. Sci. Arts*, 1893.

The conclusions of Weismann were derived principally from embryologic research, and his disciples have been chiefly recruited from embryologists. These conclusions have been supported by extensive and exhaustive investigations, which have added greatly to our knowledge of the subject. In order to account for the appearance of characters in the embryonic succession, through influences confined to the germ-plasma, Weismann invented a theory which requires the presence of distinct molecular aggregates within it, which represent the potentialities or causes. To these he has given the names of ids, idants, determinants, etc.

Weismann has, however, subsequently modified his views to a considerable extent. He has always admitted the doctrine of Lamarck to be applicable to the evolution of the types of unicellular organisms. His experiments on the effect of temperature on the production of changes of color in butterflies, showed that such changes were not only effected, but were sometimes inherited. This he endeavors to explain as follows.[1] "Many climatic variations may be due wholly or in part, to the simultaneous variation of corresponding determinants in some parts of the soma and in the germ-plasm of the reproductive cells." This is an admission of the doctrine which in 1890 I called Diplogenesis.[2] It appears to have been first propounded by Galton in 1875.

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[1] *Essays*, p. 296. For a complete account of Weismann's views, see *The Germ-Plasm*, 1893.

From what has preceded, two distinct lines of thought explanatory of the fact of organic evolution may be discerned. In one of these the variations of organisms which constitute progressive and regressive evolution appear fortuitously, and those which are beneficial survive by natural selection, while those which are not so, disappear. Characters both beneficial and useless or harmless, which are acquired by the adult organism, are not transmitted to the young, so that no education in habit or structure acquired by the adult, has any influence in altering the course of evolution. This is the doctrine of Preformation. From this point of view the cause of the variation of organisms has yet to be discovered.

The other point of view sees in variation the direct result of stimuli from within and without the organism; and holds that evolution consists of the inheritance of such variations and the survival of the fit through natural selection. This is the doctrine of Epigenesis. To this I would add that in so far as sensations or states of consciousness are present, they constitute a factor in the process, since they enable an organism to modify or change its stimuli. The position of each of these schools on each of the questions to which reference has been made, may be placed in opposition as follows:

1. Variations appear in definite directions.	1. Variations are promiscuous or multifarious.
2. Variations are caused by the interaction of the organic being and its environment.	2. Variations are "congenital" or are caused by mingling of male and female germ-plasmas.
3. Acquired variations may be inherited.	3. Acquired variations cannot be inherited.

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[1] *The Germ-Plasm*, Contemporary Science Series, 1893, p. 406.

[2] *American Naturalist*, December, 1889; published in 1890.

4. Variations survive directly as they are adapted to changing environments. (Natural selection.)	4. Variations survive directly as they are adapted to changing environments. (Natural selection.)
5. Movements of the organism are caused or directed by sensation and other conscious states.	5. Movements of organism are not caused by sensation or conscious states, but are a survival through natural selection from multifarious movements.
6. Habitual movements are derived from conscious experience.	6. Habitual movements are produced by natural selection.
7. The rational mind is developed by experience, through memory and classification.	7. The rational mind is developed by natural selection from multifarious mental activities.

It is not my object to present the available evidence on both sides of each of the questions above enumerated, for I must here be satisfied with having formulated the problem. I shall treat the subject at full length in a forthcoming book, in which I propose to submit certain facts, in support of the doctrines contained in the left-hand column of the above table. My aim will be to show in the first place, that variations of character are the effect of physical causes; and second, that such variations are inherited. The facts adduced in support of these propositions will be necessarily principally drawn from my own studies in the anatomy, ontology, and paleontology of the Vertebrata. It will be my aim, moreover, to co ordinate the facts of evolution with those of systematic biology, so that the result may be as clearly presented as possible. The failure to do this by the founders of evolutionary doctrine has given their work a lack of precision, which has been felt by systematic biologists. The detailed application of the principles of Lamarck and Darwin has been the work of their successors, and has necessarily thrown much new light on the principles themselves. We have at present ampler means than ever to consider the validity of the general propositions on which the doctrine of evolution rests.

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